

WE CLAIM:

1. A molecular memory element comprising:
a switching device;
a bit line and a word line coupled to the switching
5 device; and
a molecular storage device comprising a first
electrode, a second electrode and a molecular material
between the first and second electrodes, wherein the
switching device is coupled to the first electrode.
- 10 2. The molecular memory array of claim 1, wherein
the switching device comprises a transistor.
3. The molecular memory array of claim 2, wherein
the transistor comprises a field effect transistor.
4. The molecular memory array of claim 1,
15 comprising a row decoder coupled to the word line.
5. The molecular memory array of claim 1,
comprising a column decoder coupled to the bit line.
6. The molecular memory array of claim 1,
comprising a current preamplifier connected to the bit
20 line.
7. The molecular memory array of claim 1,
comprising a sense amplifier connected to the bit line.
8. The molecular memory array of claim 1, wherein
the second electrode of the molecular storage device is
25 coupled to ground.
9. The molecular memory array of claim 8, wherein
the array comprises volatile memory.

10. The molecular memory array of claim 9 wherein the volatile memory comprises one of DRAM or SRAM.

11. The molecular memory array of claim 8, wherein the array comprises non-volatile memory.

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12. The molecular memory array of claim 11 wherein the volatile memory comprises one of Flash or ferroelectric memory.

13. The molecular memory array of claim 1, wherein the molecular storage device comprises:

an attachment layer formed on the first electrode, wherein the attachment layer comprises an opening and wherein the molecular material is in the opening and electronically coupled to the second electrode layer; and
an electrolyte layer formed on the attachment layer.

14. The molecular memory of claim 1, wherein the molecular material comprises a molecular storage layer comprising one or more storage molecules.

15. The molecular memory of claim 1, wherein the molecular material comprises at least one molecule selected from a group comprising a porphyrinic macrocycle, a metallocene, a linear polyene, a cyclic polyene, a heteroatom-substituted linear polyene, a heteroatom substituted cyclic polyene, a tetrathiafulvalene, a tetraselenafulvalene, a metal coordination complex, a buckyball, a triarylamine, a 1,4-phenylenediamine, a xanthene, a flavin, a phenazine, a phenothiazine, an acridine, a quinoline, a 2,2'-bipyridyl, a 4,4'-bipyridyl, a tetrathiotetracene or a peri-bridged naphthalene dichalcogenide.

16. The molecular memory of claim 1, wherein the molecular material comprises at least one molecule selected from a group comprising a porphyrin, an expanded porphyrin, a contracted porphyrin, a ferrocene, a linear
5 porphyrin polymer, a porphyrinic sandwich complex or a porphyrin array.

17. The molecular memory of claim 1, wherein the molecular material is coupled to an electrode with a linker.

10 18. The molecular memory of claim 15, wherein the molecular material provides at least four oxidation states.

15 19. The molecular memory of claim 12, wherein the molecular material provides at least six oxidation states.

20. The molecular memory of claim 1, wherein the first electrode and the second electrode comprise a metal or a semiconductor.

20 21. The molecular memory of claim 20, wherein the metal comprises Al, Au, Ag, Ti, W, Cu or oxides or nitrides of metals.

22. The molecular memory of claim 20, wherein the semiconductor comprises Si, Ge, SiGe, GaAs, or ITO.

25 23. The molecular memory of claim 1, wherein the molecular storage device has a charge retention time of greater than 64 msec.

24. The molecular memory of claim 1, wherein the molecular storage device has a charge retention time determined by the intrinsic properties of the molecule.

25. The molecular memory of claim 24 wherein the
5 molecular storage device has a charge retention time of greater than 64 msec.

26. The molecular memory device of claim 1, wherein the bit line and the word line are perpendicular.

27. The molecular memory device of claim 1, wherein
10 the bit line and the word line are parallel.

28. A molecular memory array comprising:

a plurality of molecular storage elements where each molecular storage element is capable of being placed in two or more discrete states.

29. The molecular memory array of claim 28 further
15 comprising:

a plurality of bit lines and word lines coupled to the plurality of molecular storage elements such that each molecular storage element is coupled to and
20 addressable by at least one bit line and at least one word line.

30. A molecular memory device comprising:
an addressable array of molecular storage elements.

31. The molecular memory device of claim 30 further
25 comprising an address decoder that receives a coded address and generates word line signals corresponding to the coded address.

32. The molecular memory device of claim 31 further comprising a line driver coupled to the address decoder

wherein the line driver produces amplified word line signals.

33. The molecular memory device of claim 32 wherein the amplified word line signals control switches that
5 selectively couple members of the array of molecular storage elements to bit lines.

34. The molecular memory device of claim 33 wherein read/write logic coupled to the bit lines, wherein the read/write logic determines whether the molecular memory
10 devices is in a read mode or a write mode.

35. The molecular memory device of claim 33 further comprising sense amplifiers coupled to each bit line, wherein when the device is in a read mode, sense amplifiers coupled to each bit line detect an electronic
15 state of the selectively coupled molecular storage elements and produce a data signal on the bit line indicative of the electronic state of the selectively coupled molecular storage elements.

36. The molecular memory device of claim 33 wherein
20 when the device is in a write mode, the read/write logic drives a data signal onto the bit lines and the selectively coupled molecular storage elements.

37. An monolithically integrated device comprising:
logic devices configured to perform a particular
25 function; and
embedded molecular memory devices coupled to the logic devices.

38. The monolithically integrated device of claim 37 wherein the device comprises an application specific
30 integrated circuit (ASIC)

39. The monolithically integrated device of claim 37 wherein the device comprises a system on chip (SOC).

40. The monolithically integrated device of claim 37 wherein the logic devices comprise solid state
5 electronic devices.

41. The monolithically integrated device of claim 37 wherein the logic devices comprise molecular electronic devices.